



PATENT
Docket 4424/4526

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Patent Application Of:

Appellant: Shau-Lin F. Chen
Serial No.: 09/834,505
Date Filed: 13 April 2001
Title: LAYERED SOX TOLERANT NOX TRAP CATALYSTS AND
METHODS OF MAKING AND USING THE SAME
Art Unit: 1754
Examiner: Timothy Vanoy

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

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APPELLANT'S BRIEF ON APPEAL

Sir:

This is an appeal to the Board of Patent Appeals and Interferences from a Final decision by the Examiner dated 12 May 2003 wherein claims 1, 2, 9, 20, 21, 29, 34, 42, 48, 60, 62, 63, 106, and 109 are pending, 60, 62, and 63 were allowed, and 1, 2, 9, 20, 21, 29, 34, 42, 48, 106, and 109 were rejected, in a final rejection, in the above-identified patent application.

CERTIFICATE OF MAILING PURSUANT TO 37 C.F.R. SECTION 1.8

I hereby certify that this correspondence, and any documents referred to as enclosed, are being deposited, pursuant to 37 C.F.R. Section 1.8, with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to the Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on this 7th of October, 2003.

By Richard R Muccino 7 Oct 03
Richard R. Muccino
Reg. No. 32,538

date

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(1) REAL PARTY IN INTEREST.

The party named in the caption of the brief is the real party in interest.

(2) RELATED APPEALS AND INTERFERENCES.

Appellant is not aware of any other appeals or interferences which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) STATUS OF CLAIMS.

This is a statement setting out the status of all claims, pending or cancelled, and identifying the claims on appeal.

This patent application serial no. 09/834,505 was filed on 13 April 2001. Appellant filed this application with claims 1-118.

The Examiner issued a telephonic restriction requirement on 1 November 2002 to Group I claims 1-73 (catalyst) and 106-118 (method to make) and Group II claims 74-105 (method of use). Appellant provisionally elected Group I, claims 1-73 and 106-118.

The Examiner further issued a multiplicity requirement on 29 November 2002 requiring appellant to select a specific number of claims, to limit the Group I claims to 20 claims. Appellant filed an Amendment dated 26 November 2002 electing 20 claims from the claims set forth in Group I, specifically claims 1, 2, 5, 7, 8, 9, 20, 21, 29, 34, 39, 40, 41, 42, 48, 60, 62, 63, 106, and 109.

In an Examiner's Action dated 9 January 2003, the Examiner allowed claims 60, 62, and 63 and rejected claims 1, 2, 5, 7, 8, 9, 20, 21, 29, 34, 39-42, 48, 106, and 109. Appellant filed an Amendment and Response dated 9 April 2003 amending claims 1, 9, 34, 42, 106, and 109 and deleting claims 5, 7, 8, 39, 40, and 41.

On 12 May 2003 in a final Office Action, the Examiner maintained the allowance of claims 60, 62, and 63 and the rejection of claims 1, 2, 9, 20, 21, 29, 34, 42, 48, 106, and 109. Appellant filed an Amendment and Response dated 8 August 2003 amending claims 1, 9, 29, 34, 42, 48, 106, and 109 and did not add or delete any claims.

Claims 1, 2, 9, 20, 21, 29, 34, 42, 48, 60, 62, 63, 106, and 109 are pending in this application. Appellant appeals the rejection of claims 1, 2, 9, 20, 21, 29, 34, 42, 48, 106, and 109.

(4) STATUS OF AMENDMENTS.

In an advisory Action dated 25 August 2003, the Examiner entered appellant's amendments to claims 1, 9, 29, 34, 42, 48, 106, and 109.

(5) SUMMARY OF INVENTION.

Appellant's invention provides a layered catalyst composite comprising a first layer and a second layer: (a) the first layer comprising a first support, a NOx sorbent component, and a first platinum component; and (b) the second layer comprising a second support and a SOx sorbent component selected from the group consisting of MgAl₂O₄, MnO, MnO₂, and Li₂O, wherein the SOx sorbent component has a higher free energy of formation at 350°C than the NOx sorbent component. (appellant's claim 1 as amended)

Appellant's invention also provides an axial layered catalyst composite comprising an upstream section and a downstream section: (1) the downstream section comprising: (a) a downstream substrate; and (b) a first layer on the downstream substrate, the first layer comprising a first support, a NO_x sorbent component, and a first platinum component; (2) the upstream section comprising: (a) an upstream substrate; and (b) a second layer on the upstream substrate, the second layer comprising a second support and a SO_x sorbent component selected from the group consisting of MgAl₂O₄, MnO, MnO₂, and Li₂O, wherein the SO_x sorbent component has a higher free energy of formation at 350°C than the NO_x sorbent component. (appellant's claim 34 as amended)

Appellant's invention further provides a radial layered catalyst composite comprising a bottom layer, a first middle layer, and a top layer: (a) the bottom layer comprising: (i) a first support; (ii) a first platinum component; (iii) a first NO_x sorbent component selected from the group consisting of cesium components, potassium components, and cerium components; and (b) the first middle layer comprising: (i) a second support; (ii) a second SO_x sorbent component which is selected from the group consisting of BaO and MgO; and (c) the top layer comprising: (i) a third support; (ii) a third SO_x sorbent component which is MgAl₂O₄. (appellant's claim 60 as amended)

Appellant's invention further provides a method of forming a layered catalyst composite which comprises the steps of: (a) forming a first layer comprising: (i) a first support; (ii) a NO_x sorbent component; and (iii) a first platinum component; and (b) coating the first layer with a second layer comprising: (i) a second support; and (ii) a SO_x sorbent component selected from the group consisting of MgAl₂O₄, MnO, MnO₂, and Li₂O, wherein the SO_x sorbent component has a higher free energy of formation at 350°C than the NO_x sorbent component. (appellant's claim 106 as amended)

Appellant's invention further provides a method of forming a layered catalyst composite which comprises the steps of: (a) combining a water-soluble or dispersible first platinum component, a NO_x sorbent component, and a finely divided, high surface area refractory oxide with an aqueous liquid to form a first solution or dispersion which is sufficiently dry to absorb essentially all of the liquid; (b) forming a first layer of the first solution or dispersion on a substrate; (c) converting the first platinum component in the resulting first layer to a water-insoluble form; (d) combining a water-soluble or dispersible SO_x sorbent component selected from the group consisting of MgAl₂O₄, MnO, MnO₂, and Li₂O, wherein the SO_x sorbent component has a higher free energy of formation at 350°C than the NO_x sorbent component, and a finely divided, high surface area refractory oxide with an aqueous liquid to form a second solution or dispersion which is sufficiently dry to absorb essentially all of the liquid; (e) forming a second layer of the second solution or dispersion on the first layer; and (f) converting the second platinum component in the resulting second layer to a water-insoluble form.

(appellant's claim 109 as amended)

(6) THE ISSUE.

The issue is whether or not claims 1, 2, 9, 20, 21, 29, 34, 42, 48, 106, and 109 are obvious under 35 U.S.C. Section 103(a) over United States Patent no. 5,792,436 (*Feeley et al.*).

(7) GROUPING OF CLAIMS.

Claims 60, 62, and 63 were allowed. Claims 1, 2, 9, 20, 21, 29, 34, 42, 48, 106, and 109 were rejected. Claims 1, 2, 9, 20, 21, and 29 stand together.

Claims 34, 42, and 48 stand together. Claims 60, 62, and 63 stand together.
Claim 106 stands by itself. Claim 109 stands by itself.

(8) ARGUMENT.

The Issue

Whether or not claims 1, 2, 9, 20, 21, 29, 34, 42, 48, 106 and 109 are obvious over United States Patent no. 5,792,436 (*Feeley et al.*).

The Examiner has rejected claims 1, 2, 9, 20, 21, 29, 34, 42, 48, 106, and 109 under 35 U.S.C. Section 103(a) as being obvious over United States Patent no. 5,792,436 (*Feeley et al.*). The Examiner states that *Feeley et al.* discloses in Example 3 a catalyst comprising a 1st underlayer containing an oxidation catalyst, such as platinum supported on alumina, and a 2nd SO_x-sorbing overlayer, such as an alkali metal and/or manganese oxide supported on a 2nd support (col. 6, lines 39-41 and 47-51 and claims 6-9). The Examiner states that *Feeley et al.* further discloses a method for making the catalyst comprising (Example 3, sections A and B) combining a solution of platinum and a solution of alumina powder to provide a slurry of particles; dipping a cordierite, honeycomb-type substrate into this slurry of particles so as to "washcoat" the Pt/Al₂O₃ onto the honeycomb-type substrate, and drying and calcining the resulting honeycomb-type substrate supporting the Pt/Al₂O₃; (example 3, section C) mixing the SO_x sorbent and the alumina together and adding water to this mixture to produce a slurry of fine particles of SO_x sorbent/Al₂O₃; dipping the Pt/Al₂O₃ layered substrate into this slurry of SO_x sorbent/Al₂O₃ so that the SO_x sorbent/Al₂O₃ is coated over the Pt/Al₂O₃ layer, and calcining the resulting catalytic composition to form a substrate containing a

Pt/Al₂O₃ underlayer and a SO_x sorbent/Al₂O₃ overlayer, in a manner rendering obvious the steps recited in appellants' claim 109.

The Examiner argues that the difference between appellants' claim 109 and Example 3 in *Feeley et al.* is that appellants' claims recite that the SO_x sorbent is selected from MgAl₂O₄, MnO, MnO₂, and Li₂O, whereas *Feeley et al.* discloses in Example 3 the use of SrO as the SO_x sorbent. The Examiner maintains that *Feeley et al.* (col. 11, lines 27-35) reports that the SO_x sorbent may be selected from a variety of compounds including an alkali metal or an oxide of manganese. The Examiner concludes that it would have been obvious to modify Example 3 in *Feeley et al.* by substituting an alkali metal or an oxide of manganese in lieu of the SrO to arrive at appellant's catalyst and method for making the same because *Feeley et al.* (col. 11, lines 27-35) states that the SrO of Example 3 and the alkali metals and manganese oxides of col. 11, lines 27-35 are functionally equivalent SO_x sorbents. Appellant's claims as amended obviate the Examiner's rejection.

In summary, *Feeley et al.* does not teach appellant's concept of a "basicity" gradient in a layered catalyst composite. Appellant's layered catalyst composite comprises a less basic layer (Mg, Mn, Li, etc.) in front of a more basic layer (Ba, Cs, K, etc.). The less basic layer preferentially removes SO_x from a gaseous stream before the stream reaches the more basic NO_x sorption layer, thereby protecting the NO_x sorption layer. When the SO_x sorption layer becomes saturated with SO_x, the deSO_x cycle is begun. The basicity gradient from the top layer to the bottom layer or axially from the front layer to the rear layer are the essence of appellant's invention. *Feeley et al.* does not teach appellant's concept of a "basicity" gradient in a layered catalyst composite. *Feeley et al.* discloses a Sr/Al layer on the top (high basicity) and a Pt/Al layer (low basicity) on the bottom layer.

As set out above, appellant has amended independent claims 1, 34, 106, and 109 and the claims dependent thereon, to recite that the first layer further comprises a NO_x sorbent component and that the SO_x sorbent component in the second layer

has a higher free energy of formation at 350°C than the NOx sorbent component in the first layer. This amendment to the claims is supported appellant's specification as follows:

As set out above, the present invention employs a second or top layer of a SOx sorbent component which acts as a sulfur oxide absorbing layer to selectively and reversibly absorb sulfur oxides over nitrogen oxides and thereby provide a sulfur guard for the NOx trap component/three-way conversion catalyst. The SOx sorbent component in the SOx absorbing layer is a metal oxide, which is less basic than the metal oxide in the NOx absorbing layer. The less basic SOx sorbent component forms SOx complexes (sulfates) that are less stable than the SOx complexes formed with the more basic NOx trap components. The SOx sorbent components of the present invention have a free energy of formation from about 0 to about -90 Kcal/mole at 350°C., preferably from about 0 to about -60 Kcal/mole at 350°C., and more preferably from about -30 to about -55 Kcal/mole at 350°C. The free energy of formation is the free-energy change for a reaction in which a substance in its standard state is formed from its elements in their standard states. The free energy of a system is the internal energy of a system minus the product of its temperature and its entropy, that is $G = H - TS$, where G is the Gibbs free energy, H is enthalpy, T is absolute temperature, and S is entropy. Figure 1 shows the free energy of formation in Kcal/mole at 350°C. for a number of metal oxides reacting to form nitrates, sulfates, carbonates, nitrites, and sulfites. In general, metals having a free energy of formation with NOx greater than about 0 Kcal/mole at 350°C. (i.e., 10 Kcal/mole) will not readily adsorb NOx while metals having a free energy of formation with SOx lower than about -90 Kcal/mole at 350°C. (i.e., -100 Kcal/mole) will form very stable sulfate but not readily desorb SOx. (appellant's specification at page 16, line 21, to page 17, line 10)

The top layer comprises SOx absorbing components which will not substantially absorb NOx under the operating conditions, e.g., from about 300°C. to about 600°C. The medium temperature regeneration SOx traps selectively absorb SOx so that the SOx traps will not be saturated with nitrate salts in the lean mode and consequently lose their SOx-trap capacity. The SOx sorbent

component is capable of selectively absorbing SO_x over NO_x in a temperature range from about 100°C. to about 600°C. and capable of desorbing SO_x in a temperature range from about 500°C. to about 700°C. Preferably, the SO_x sorbent component is capable of selectively absorbing SO_x over NO_x in a temperature range from about 150°C. to about 475°C., more preferably in a temperature range from about 200°C. to about 450°C., and most preferably in a temperature range from about 250°C. to about 450°C. Preferably, the SO_x sorbent component is capable of desorbing SO_x over NO_x in a temperature range from about 500°C. to about 700°C., preferably in a temperature range from about 520°C. to about 658°C., more preferably in a temperature range from about 535°C. to about 675°C., and most preferably in a temperature range from about 550°C. to about 650°C. Nonlimiting illustrative examples of SO_x sorbent components may be selected from the group consisting of oxides and aluminum oxides of lithium, magnesium, calcium, manganese, iron, cobalt, nickel, copper, zinc, and silver. More preferred SO_x sorbent components may be selected from the group consisting of MgO, MgAl₂O₄ (or hydrotalcite with MgO/Al₂O₃ from 9/1 to 1/9), MnO, MnO₂, and Li₂O. The most preferred SO_x sorbent components are MgO and Li₂O. (appellant's specification at page 17, line 16, to page 18, line 5)

Appellant's invention, as defined in the amended claims, pertains to a layered catalyst composite comprising a first layer and a second layer. The first layer comprises a first support, a NO_x sorbent component, and a first platinum component. The second layer comprises a second support and a SO_x sorbent component selected from the group consisting of MgAl₂O₄, MnO, MnO₂, and Li₂O. The SO_x sorbent component has a higher free energy of formation at 350°C than the NO_x sorbent component.

The present invention relates to a thermally stable, layered catalyst composite of the type generally referred to as a three-way conversion catalyst (TWC). TWC catalysts are polyfunctional because they have the ability to substantially simultaneously catalyze the oxidation of hydrocarbons and carbon monoxide and the reduction of nitrogen oxides. The layered catalyst composites of

the present invention have a sulfur oxide absorbing layer before or above a nitrogen oxide absorbing layer. The sulfur oxide absorbing layer selectively and reversibly absorbs sulfur oxides over nitrogen oxides and thereby alleviates sulfur oxide poisoning of the three-way conversion catalyst. Because SOx poisoning of the three-way conversion catalysts is minimized, the layered catalyst composites are able to maintain long term activity and effectively oxidize hydrocarbons and carbon monoxide and reduce nitrogen oxide compounds. (appellant's specification at page 13, line 24, to page 14, line 3)

The *Feeley et al.* reference discloses a method for removing pollutants comprising nitrogen oxides and sorbable components comprising sulfur oxides and phosphorus oxides from a lean gaseous stream. The method comprises (a) in a trapping period, passing the gaseous stream within a sorbing temperature range through a catalyzed trap member comprising a combination of a regenerable sorbent material and an oxidation catalyst, and sorbing at least some of the sorb/able components into the sorbent material to thereby provide a sorbable component-depleted gaseous stream exiting the catalyzed trap member; (b) in a desorbing period, introducing a combustible component into the gaseous stream upstream of the catalyzed trap member and combusting the combustible component in the presence of the oxidation catalyst, the combustible component being introduced in an amount which is limited in order to maintain the bulk composition of the gaseous stream lean but which is enough to heat at least a portion of the sorbent material to within a desorbing temperature range to thereby thermally desorb the sorbable component from the sorbent material and provide a sorbable component-enriched gaseous stream exiting the catalyzed trap member; and (c) passing the sorbable component-depleted stream to a catalytic treatment zone for the abatement of the pollutants and by-passing the sorbable component-enriched stream around the catalytic treatment zone. *Feeley et al.* at col. 15, lines 15-44.

In summary, *Feeley et al.* does not teach a "basicity gradient" from the top layer to the bottom layer with the bottom layer being the most alkaline (Cs, K, Ba, etc.) and forming the most stable (most negative delta-G, free energy of formation) NOx and SOx salt. *Feeley et al.* also does not teach that the top layers should have the least basic components (least negative or even positive delta-G, free energy of formation, for nitrate formation) so that sulfate can be formed without the nitrate being formed. In fact, *Feeley et al.* teaches just the opposite. *Feeley et al.* teaches that the bottom layer has Pt on alumina and that the top layer has Sr on alumina. Hence, *Feeley et al.* teaches a more basic top layer than bottom layer, and the top layer will trap both SOx and NOx.

As set out above, appellant has amended claims 1, 34, 106, and 109 to recite that the first layer further comprises a NOx sorbent component and that the SOx sorbent component in the second layer has a higher free energy of formation at 350°C than the NOx sorbent component in the first layer. *Feeley et al.* does not teach appellant's concept of a "basicity" gradient in a layered catalyst composite. Accordingly, the Examiner's rejection of claims 1, 2, 9, 20, 21, 29, 34, 42, 48, 106 and 109 under 35 U.S.C. Section 103(a) as being obvious over *Feeley et al.* should be withdrawn.

Obviousness of a composition or process must be predicated on something more than it would be obvious "to try" the particular component recited in the claims or the possibility it will be considered in the future, having been neglected in the past. *Ex parte Argabright et al.* (POBA 1967) 161 U.S.P.Q. 703. There is usually an element of "obvious to try" in any research endeavor, since such research is not undertaken with complete blindness but with some semblance of a chance of success. "Obvious to try" is not a valid test of patentability. *In re Mercier* (CCPA 1975) 515 F2d 1161, 185 U.S.P.Q. 774; *Hybritech Inc. v. Monoclonal Antibodies. Inc.* (CAFC 1986) 802 F2d 1367, 231 U.S.P.Q. 81; *Ex parte Old* (BPAI 1985) 229 U.S.P.Q. 196; *In re Geiger* (CAFC 1987) 815 F2d

686, 2 U.S.P.Q.2d 1276. *In re Dow Chemical Co.* (CAFC 1988) F2d, 5 U.S.P.Q.2d 1529. Patentability determinations based on that as a test are contrary to statute. *In re Antonie* (CCPA 1977) 559 F2d 618, 195 U.S.P.Q. 6; *In re Goodwin et al.* (CCPA 1978) 576 F2d 375, 198 U.S.P.Q. 1; *In re Tomlinson et al.* (CCPA 1966) 363 F2d 928, 150 U.S.P.Q. 623. A rejection based on the opinion of the Examiner that it would be "obvious to try the chemical used in the claimed process which imparted novelty to the process does not meet the requirement of the statute (35 U.S.C. 103) that the issue of obviousness be based on the subject matter as a whole. *In re Dien* (CCPA 1967) 371 F2d 886, 152 U.S.P.Q. 550; *In re Wiaains* (CCPA 1968) 397 F2d 356, 158 U.S.P.Q. 199; *In re Yates* (CCPA 1981) 663 F2d 1054, 211 U.S.P.Q. 1149. Arguing that mere routine experimentation was involved overlooks the second sentence of 35 USC 103. *In re Saether* (CCPA 1974) 492 F2d 849, 181 U.S.P.Q. 36. The issue is whether the experimentation is within the teachings of the prior art. *In re Waymouth et al.* (CCPA 1974) 499 F2d 1273, 182 U.S.P.Q. 290. The fact that the prior art does not lead one skilled in the art to expect the process used to produce the claimed product would fail does not establish obviousness. *In re Dow Chem. Co.* (CAFC 1988) 5 U.S.P.Q.2d 1529.

The provisions of Section 103 must be followed realistically to develop the factual background against which the Section 103 determination must be made. It is not proper within the framework of Section 103 to pick and choose from any one reference only so much of it as will support a given position to the exclusion of other parts necessary for the full appreciation of what such reference fairly suggests to one of ordinary skill in the art. The references of record fail to teach or suggest appellant's invention as a whole.

CONCLUSION

There is no disclosure of facts in the prior art, which support a legal conclusion that the claimed invention was obvious at the time it was made. It is a well settled principle that prior patents are references only for what they clearly disclose or suggest and that it is not proper use of a patent as a reference to modify its structure to one, which the reference does not suggest.

Appellant's brief has effectively rebutted the position of the Patent Office. The burden of going forward with proofs to support its position as to obviousness of the claimed invention has shifted to the Patent Office. No additional proofs have been submitted.

In view of the above remarks, the Examiner's rejection of claims 1, 2, 9, 20, 21, 29, 34, 42, 48, 106, and 109 should be reversed so that the claims may be allowed to issue.

Appellant's attorney authorizes the Examiner to charge Deposit Account 13-4822 if there are any additional charges in connection with this matter.

Respectfully submitted,
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(9) APPENDIX

Appellant's claims 1, 2, 9, 20, 21, 29, 34, 42, 48, 60, 62, 63, 106, and 109
on appeal

1. A layered catalyst composite comprising a first layer and a second layer:

(a) the first layer comprising a first support, a NO_x sorbent component, and a first platinum component; and

(b) the second layer comprising a second support and a SO_x sorbent component selected from the group consisting of MgAl₂O₄, MnO, MnO₂, and Li₂O, wherein the SO_x sorbent component has a higher free energy of formation at 350°C than the NO_x sorbent component.

2. The layered catalyst composite as recited in claim 1, wherein the first and second supports are the same or different and are compounds selected from the group consisting of silica, alumina, and titania compounds.

9. The layered catalyst composite as recited in claim 1, wherein the SO_x sorbent component is Li₂O.

20. The layered catalyst composite as recited in claim 1, wherein the second layer comprises from about 0.03g/in³ to about 2.4g/in³ of the SO_x sorbent component.

21. The layered catalyst composite as recited in claim 20, wherein the second layer comprises from about 0.3g/in³ to about 1.8g/in³ of the SO_x sorbent component.

29. The layered catalyst composite as recited in claim 1, comprising:

- (a) in the first layer;
 - (i) from about 0.15g/in³ to about 2.7g/in³ of the first support;
 - (ii) at least about 1g/ft³ of the first platinum component;
 - (iii) at least about 1g/ft³ of a first platinum group metal component other than platinum;
 - (iv) from about 0.025g/in³ to about 0.7g/in³ of the NO_x sorbent component selected from the group consisting of alkaline earth metal oxides, alkali metal oxides, and rare earth metal oxides; and
 - (v) from about 0.025g/in³ to about 0.7g/in³ of a first zirconium component; and
- (b) in the second layer;

- (i) from about 0.15g/in³ to about 2.7g/in³ of the second support;
- (ii) from about 0.3g/in³ to about 1.8g/in³ of the SOx sorbent component;
- (iii) at least about 1g/ft³ of a second platinum group component;
- (iv) at least about 1g/ft³ of a second platinum group metal component other than platinum; and
- (v) from about 0.025g/in³ to about 0.7g/in³ of a second zirconium component.

34. An axial layered catalyst composite comprising an upstream section and a downstream section:

- (1) the downstream section comprising:
 - (a) a downstream substrate; and
 - (b) a first layer on the downstream substrate, the first layer comprising a first support, a NOx sorbent component, and a first platinum component;
- (2) the upstream section comprising:
 - (a) an upstream substrate; and
 - (b) a second layer on the upstream substrate, the second layer comprising a second support and a SOx sorbent component selected from the group consisting of MgAl₂O₄, MnO, MnO₂, and Li₂O, wherein the SOx sorbent

component has a higher free energy of formation at 350°C than the NOx sorbent component.

42. The axial layered catalyst composite as recited in claim 34, wherein the SOx sorbent component is Li₂O.

48. The axial layered catalyst composite as recited in claim 34, comprising:

- (a) in the first layer;
 - (i) from about 0.15g/in³ to about 2.0g/in³ of the first support;
 - (ii) at least about 1g/ft³ of the first platinum component;
 - (iii) at least about 1g/ft³ of a first platinum group metal component other than platinum;
 - (iv) from about 0.025g/in³ to about 0.5g/in³ of the NOx sorbent component selected from the group consisting of alkaline earth metal oxides, alkali metal oxides, and rare earth metal oxides; and
 - (v) from about 0.025g/in³ to about 0.5g/in³ of a first zirconium component; and
- (b) in the second layer;
 - (i) from about 0.15g/in³ to about 2.0g/in³ of the second support;
 - (ii) from about 0.3g/in³ to about 1.8g/in³ of the SOx sorbent

component;

- (iii) at least about 1g/ft³ of a second platinum group component;
- (iv) at least about 1g/ft³ of a second platinum group metal component other than platinum; and
- (v) from about 0.025g/in³ to about 0.5g/in³ of a second zirconium component.

60. A radial layered catalyst composite comprising a bottom layer, a first middle layer, and a top layer:

(a) the bottom layer comprising:

- (i) a first support;
- (ii) a first platinum component;
- (iii) a first NO_x sorbent component selected from the group consisting of cesium components, potassium components, and cerium components; and

(b) the first middle layer comprising:

- (i) a second support;
- (ii) a second SO_x sorbent component which is selected from the group consisting of BaO and MgO; and

(c) the top layer comprising:

- (i) a third support;
- (ii) a third SO_x sorbent component, which is MgAl₂O₄.

62. The radial layered catalyst composite as recited in claim 60, wherein the second SO_x sorbent component in the first middle layer is BaO.

63. The radial layered catalyst composite as recited in claim 60, wherein the second SO_x sorbent component in the first middle layer is MgO.

106. A method of forming a layered catalyst composite which comprises the steps of:

(a) forming a first layer comprising:

- (i) a first support;
- (ii) a NO_x sorbent component; and
- (iii) a first platinum component; and

(b) coating the first layer with a second layer comprising:

- (i) a second support; and
- (ii) a SO_x sorbent component selected from the group consisting of MgAl₂O₄, MnO, MnO₂, and Li₂O, wherein the SO_x sorbent component has a higher free energy of formation at 350°C than the NO_x sorbent component.

109. A method of forming a layered catalyst composite which comprises the steps of:

(a) combining a water-soluble or dispersible first platinum component, a NO_x sorbent component, and a finely divided, high surface area refractory oxide with an aqueous liquid to form a first solution or dispersion which is sufficiently dry to absorb essentially all of the liquid;

(b) forming a first layer of the first solution or dispersion on a substrate;

(c) converting the first platinum component in the resulting first layer to a water-insoluble form;

(d) combining a water-soluble or dispersible SO_x sorbent component selected from the group consisting of MgAl₂O₄, MnO, MnO₂, and Li₂O, wherein the SO_x sorbent component has a higher free energy of formation at 350°C than the NO_x sorbent component, and a finely divided, high surface area refractory oxide with an aqueous liquid to form a second solution or dispersion which is sufficiently dry to absorb essentially all of the liquid;

(e) forming a second layer of the second solution or dispersion on the first layer; and

(f) converting the second platinum component in the resulting second layer to a water-insoluble form.